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XLVII.—*On the Development of the Ova of the Nudibranchiate Mollusca.* By John Reid, M.D., Fellow of the Royal College of Physicians of Edinburgh, and Professor of Anatomy and Medicine in the University of St. Andrews.

[With a Plate.]

The following observations upon the development of the Nudibranchiate Mollusca were made on the ova of the *Doris bilamellata, Doris tuberculata, Goniodoris Barvicensis, Polycera quadrilineata, Dendronotus arborescens, Doto coronata**, and a species of *Eolis* having numerous flattened papillæ, depressed and imbricated, arranged in fifteen or sixteen distinct rows, which I have not been able to refer to any of the species of that genus, the descriptions of which have yet come under my notice.

In the middle of last September I procured several specimens of *Polycera quadrilineata* found together near low-water mark, in each of which there was placed immediately beneath the external integuments of the upper surface a large white mass, slightly lobulated, lying behind and on each side of the heart, and prolonged forward as far as the external orifices of the reproductive organs. Two pairs of the animals were kept in separate vessels and daily supplied with fresh sea-water. Eight days after this one of the pairs was seen *in coitu*, lying side by side, the head of the one looking towards the tail of the other, and having the right edges of their bodies in close apposition. When examined twenty-fours later neither had spawned, but two hours after this one had spawned, and the other was in the act of spawning. The spawn was seen to issue very slowly from the dilated vagina, and the animal very gradually shifted its position to permit the spawn to assume a ribbon-form, and cause it to adhere by one of its

* In naming these animals I have followed Messrs. Alder and Hancock in their 'Synopsis of British Nudibranchiate Mollusca,' in their beautiful monograph published by the Ray Society in 1845. These gentlemen consider the *Goniodoris Barvicensis* to be a variety of *Goniodoris nodosa.*

borders to the object upon which it was deposited. The process of spawning did not seem to occupy any very great length of time. The other pair was seen *in coitu* nine days after I had taken them home, and when examined thirteen hours after this neither had spawned, but two hours later one had spawned and the other was spawning. The animals by spawning became considerably reduced in size. They were kept alive for three weeks, and they deposited small portions of spawn between ten and fourteen days after the first spawning. It does not however appear to be absolutely necessary for the production of fertile ova in all, if in any of the individuals of the Nudibranchiate Mollusca, that a coitus should have so shortly preceded spawning as was observed in the *Polycera*, for an *Eolis* which was kept strictly confined in a vessel by itself, deposited, on the tenth and again on the thirty-second day of its isolation, abundance of fertile ova. During the high spring tides at the end of last February, I found near low-water mark several large assemblages of *Goniodoris Barvicensis* and *Doris bilamellata* among the rocks, collected for the purpose of breeding*. In one of these groups there must have been at least between sixty and seventy individuals of the *G. Barvicensis*, and abundance of their spawn adhered to the surface of the rocks, and in one place a portion about six inches square was almost completely covered by it. Many of the *Doris bilamellata* had also spawned, and were collected in smaller, more numerous and scattered groups, the greater number of which were farther from low-water mark and in more exposed situations than those of the *G. Barvicensis*. These assemblages do not break up for some time, but continue to occupy nearly the same position, and the animals composing them spawn more than once. I found some individuals still lingering among the rocks, and recent spawn deposited, as late as the end of April. Several pairs of the *Doris tuberculata* were also observed, and I procured four specimens of *Dendronotus arborescens* and two specimens of the *Eolis* mentioned above. The individuals of the two last genera mentioned were not found in pairs, and these, along with several specimens of *Goniodoris Barvicensis* and *Doris bilamellata*, were taken home and kept until they had spawned. About the same time I procured several specimens of *Doto coronata* from the deep sea adhering to *Plumularia falcata* and *Thuiaria thuia*, which were also kept alive, and began to spawn about the middle of March. Near the end of March I found a considerable quantity of the spawn of the *Doris tuberculata* adhering to the under surface of the ledges of rock near low-water mark.

The spawn of the *Doris bilamellata*, *D. tuberculata*, *Doto coro-*

* From the unusual mildness of this spring, the breeding-season may have commenced earlier than usual.

nata and *Polycera quadrilineata* is of a ribbon-shape and of a white colour, adhering by one of its edges to the substance upon which it is deposited; while in the *Goniodoris Barvicensis, Dendronotus arborescens* and in the *Eolis,* it assumes more or less the shape of a rounded chord. The ribbon-shaped spawn of the *Polycera quadrilineata* formed a small segment of a circle, and measured between half an inch and an inch in length, and about three-twelfths of an inch in height; that of the *Doris bilamellata* a large segment of a small circle, measuring in some cases eight-twelfths of an inch in height; while that of the *Doto coronata,* wound in a spiral manner round the branch of the zoophyte to which it adhered, and its free edge, instead of being straight as in the other ribbon-shaped spawn mentioned, presented under the microscope numerous and regular convexities. The spawn of the *Doris bilamellata* consists of two laminæ of a structureless substance, between the layers of which, except for a small space near the edges, very numerous small ova are placed. These ova are firmly fixed in their position by a substance of the same nature as the external laminæ which unites them together, and fills up the interstices among the ova. The ribbon thus formed is very elastic and tough, but when the ova are about to escape it becomes soft and gelatinous, the laminæ separate at the edges, and at a later period may give way at different parts. This description applies to the spawn of the *D. tuberculata* and *Doto coronata,* and probably also to the *Polycera quadrilineata,* but my notes do not enable me to speak positively of this last. The spawn of the *Goniodoris Barvicensis* is either white or of a faint pink colour, has a disposition to assume the semicircular form, and some portions were from one to two inches in length, and from a quarter to nearly half an inch in circumference, and though rounded, it shows a slight tendency to the ribbon form. Its structure is essentially the same as that of the *D. bilamellata,* with this difference, that the external lamina approaches the cylindrical form with the ova arranged in the centre. The spawn of the *Dendronotus arborescens* was in the form of a small, long and waving chord, destitute of the strength and elasticity of the ribbon-shaped spawn, of a faint pink colour, attached to a branch of a *Plumularia,* along the side of which it formed a series of festoons. The circumference of this chord was formed of a transparent membranous-looking substance having no distinct structure, and the ova which occupied the interior were easily displaced and forced outwards. The spawn of the *Eolis* was deposited upon the inner surface of the vessel in which it was kept and upon a stone, and consisted of a small chord of a pale pink colour about one-twelfth of an inch in diameter, arranged in a close spiral form, the turns of which lay almost in apposition, and were surrounded and connected together, and to the surface of the object upon which they were placed, by a transparent structureless substance. This chord when arranged in this manner made up a larger chord from three-twelfths to four-twelfths of an inch in diameter and several inches in length, which formed several coils, some of which crossed or were superimposed upon others. The structure of this chord was the same as that of the *Dendronotus arborescens*.

When the ova are examined under the microscope soon after the extrusion of the spawn, each is seen to consist of a thin transparent membranous case (Pl. X. fig. 1 *a*), with a round, smooth and opake body in its centre (fig. 1 *b*). This membranous case (chorion), which I shall designate the *case-membrane*, is of a circular or oval form, is larger than what is sufficient to contain the opake body within it, and its walls appear to be composed of at least two distinct laminæ*. The opake body within is of a round form, and is chiefly composed of minute cells (nuclei), intermixt with a structureless substance which I suppose to be semifluid, and the whole is inclosed in an external transparent membrane (vitelline membrane†). I shall restrict the term *ovum* to this opake body inclosed in the *case-membrane*‡. The ova of the *Doris bilamellata* vary in size from about 1-250th to 1-280th of an inch in diameter, those of the *Eolis* were nearly of the same size, while those of the *Doris tuberculata* were considerably larger and those of *Doto coronata* smaller than this. The minute cells (nuclei) composing the greater part of the vitelline mass are of a round or oval shape (fig. 3), vary in size in the *Doris bilamellata* from 1-6000th to 1-9000th—the greater number being from the 1-7000th to 1-8000th—of an inch in diameter, and no nucleoli were observed in their interior. A very great number of these ova were examined when subjected to very different degrees of pressure, and their structure appeared to be uniform, presenting no differences at different parts, and entirely composed of the materials we have described. I endeavoured to discover a clear cell in the centre of the vitelline mass, similar to that described by Kölliker and Dr. Bagge as existing in the ova of different species of *Ascaris*, and which plays so important a part in the cleaving of the yolk; but if such a cell exists, it escaped my notice from the opacity of the yolk. No evidence of the presence of this cell was obtained in any of the subsequent changes through which the ovum passed. In the spawn of the *Polycera quadrilineata, Doto coronata, Doris*

* I observed these laminæ separated from each other in some parts by a distinct interval in several ova of the spawn of the *Eolis*.

† Fig. 2 is a diagram showing the external or vitelline membrane imperfectly filled with its contents.

‡ No doubt the *case-membrane* is an accessory part of the *ovum*, and it is for convenience sake that I use the latter term in this restricted sense.

bilamellata, D. tuberculata and *Dendronotus arborescens,* one ovum is generally contained in each *case-membrane*; but in some portions of the spawn of the *Doris bilamellata,* two and even three ova were found in the same *case-membrane.* The greater number of the *case-membranes* in the spawn of the *Eolis* contained each two, three, four, and even five ova. The size of the case-membranes varies according to the number of ova which it contains. In the spawn of the *Eolis* the shape of the *case-membranes* is easily altered by external pressure, so that instead of being circular or oval they were frequently multangular.

One and sometimes two small transparent cells were seen in some of the ova examined soon after being spawned, adhering feebly to the outer surface of the external membrane (fig. 2 *a*) at the line of the first division of the ovum. These transparent cells were in general very easily detached by pressure, and were sometimes seen lying loose within the *case-membrane.*

I shall first describe the changes observed in the ova of the *Doris bilamellata* in the course of their development. A few hours after the extrusion of the spawn, a transverse groove presents itself on the surface of the ovum (fig. 4), and this gradually deepens and divides it into two equal parts, each part being of a circular form and completely inclosed in its own external membrane (fig. 5). Each of these again undergoes a bipartite division (fig. 6), and the four equal parts of which the ovum now consists proceed in their turn to divide in the same manner (fig. 7). In a portion of spawn examined between eleven and twelve hours after its extrusion, all the ova, with the exception of a very few which presented the primary division into two, had divided into four parts; and eight hours after this, or about nineteen hours from the time of spawning, most of them had divided into eight, some still consisted of four, and a few of six parts. Examined after twenty-seven hours from the time of spawning the ova had the appearance represented in fig. 8, and after fifty hours the appearance represented in fig. 9*. At the end of about seventy-five hours the cells of the ovum were still more subdivided, as is shown in fig. 10. Between this period and the end of the fifth day, the division of the cells of the ovum appeared to have reached its utmost limit, and the ovum gradually changed its shape, becoming somewhat elongated and broader at one end and narrower at the other, as in fig. 11. Up to this time these cells, though adhering by those parts of their external surfaces in contact, could sometimes be detached from each other by the application of pressure—more readily however at the earlier periods

* It is necessary to employ a fresh portion of spawn in each observation, as the development of the ova in those portions of the spawn used in such examinations under the microscope is very seriously disturbed.

of their division; but after this they began to coalesce, though some might be separated from the rest still later. Each of the small cells into which the ovum had divided measured from the 1-1500th to 1-2000th of an inch in diameter, and consisted of a cell-membrane, with several of the minute cells of which the ovum was originally chiefly composed placed like nuclei in its interior (fig. 12). The ovum at the time of its extrusion may perhaps be considered to be a single large cell with a great number of minute cells or nuclei in its interior. During the subdivision of this large cell into a number of smaller cells, I could detect no changes, after repeated examinations, in the form of the minute cells or nuclei, and none in their arrangement which were not apparently produced by the bending inwards of the external or vitelline membrane to effect the subdivision. I do not mean to assert that these central nuclei were not the efficient agents in producing these changes; I only wish to state that I was unable to detect any alteration in the form or in the arrangement of these nuclei preceding these subdivisions. At the end of the sixth day no additional change had taken place in the external form of the ovum, but the cells into which it had divided were continuing to coalesce, and minute cilia were observed on the upper surface of the broad extremity. On the eighth day it had assumed the form represented in fig. 13; its circumference had become somewhat translucent, especially at the lower and middle parts, where the external layer of cells had separated themselves from the others, and coalesced to form the commencement of the shell (fig. 13 *a*). The incipient shell contained many of the minute cells or nuclei, and bands of them passed between different parts of its inner surface and the dark mass in the interior. The cilia on the broad extremity had become larger and more active in their movements, and traces were observed of the division of this end into the *ciliated discs* (fig. 13 *c*) and the *foot* (fig. 13 *d**). The cells into which the ovum had divided had now almost disappeared, while the minute cells or nuclei of which the ovum originally chiefly consists seemed to be as numerous as ever, and were diffused, except where the shell was forming, through a glutinous-looking structureless substance. It is now entitled to the term of *embryo*. Instead of describing in their order of succession the different changes through which the embryo passes until it leaves the case-membrane and swims at large, I shall first describe its structure at that period, as this will save a good deal of repetition, and also render the description more easily followed. Some of the embryos left their *case-membrane* about the end of the fourteenth day after spawning, but the whole had not escaped until three or four

* These parts are indicated by the same letters of reference in a more advanced stage of their development in fig. 17.

days later. The *case-membrane* previous to the escape of the embryo becomes gradually thinner, and at last either entirely disappears or is reduced to shreds. This change in the *case-membrane* may probably be in some measure caused by the incessant strokes of the long cilia of the *ciliated discs* upon its inner surface during the active revolutions of the embryo round its interior. The embryo at the time of its liberation is provided with a shell (figs. 25 and 20 *a*), considerably longer in its antero-posterior than in its transverse diameter, from which it can protrude the upper part of its body and retract it at pleasure. Fig. 20 is a representation of the embryo when protruded from its shell, and fig. 21 when entirely drawn into its interior. The embryo with its shell is at this period considerably larger than the ovum at the time of its extrusion. Some of them measured about 1-145th of an inch in length and 1-200th in the antero-posterior diameter; others 1-170th in the former and 1-250th in the latter direction. The parts which can be protruded from the shell are two large and prominent ciliated discs (fig. 20 *c*), and a projecting process* attached to the upper part of the anterior surface of the body (fig. 20 *d*). The lower surface of this projecting process or *foot* is covered by a hard plate (fig. 20 *g*), which closely adheres to it and moves along with it. The *ciliated discs* are higher in front than behind, and are separated in front by a deep notch and by a shallower one behind. They are very contractile, and present very different appearances at different times; and their superior surface is provided with a thickened margin, to the upper and outer edge of which a row of long and strong cilia is attached, by whose movements they can swim rapidly in various directions through the water. When these discs are elevated and in the vertical position, as represented in figs. 20 and 18, the parts connecting their margins to the body of the embryo are translucent, and they may now be contracted from before backwards and a number of the central cilia collected into a tuft; or if the embryo be about to retire into the shell, they are pressed together, the translucent texture connecting their thickened margins to the body contracts and pulls them downwards, and the *foot* with its hard plate is raised, as is represented in fig. 21. This plate now acts as an imperfect operculum. When the embryo, on the other hand, is about to swim, the *ciliated discs* are thrown apart and flattened, as is represented in figs. 16 and 19; and in this position each disc approaches the circular form, is hollow on the upper surface, and their thickened margins are prolonged inwards along the edges of the anterior notch, at the bottom of which they are continuous.

* To an exactly similar structure in the embryo of the *Asplysia* Van Beneden (Annales des Sciences Naturelles, tom. xv. p. 123, 1841) has given the name of *foot*, and we have here retained the appellation.

In the bottom of this anterior notch, immediately in front of the point where the thickened margins of the discs become continuous, and at the base of the upper surface of the *foot*, the mouth (fig. 16 *y*), which is formed by a simple rounded aperture, is placed. The long cilia attached to the outer edge of the upper surface of the thickened margin of the discs are when at rest first bent inwards at an acute angle as far as the inner edge of the thickened margin, and then project upwards and outwards, but become more straight when in a state of action. The upper surface of the *foot* and the sides of the mouth are provided with cilia considerably smaller than the locomotive ones attached to the margin of the disc, and still smaller cilia are placed upon the hollow upper surface of the discs and other parts of the embryo outside the shell. Two very obvious and transparent cells (figs. 16 and 17 *x*), possessing much more refractive power than the other parts of the embryo, are placed in the base of the foot, at the sides of the gullet and immediately below the mouth. Each of these is apparently inclosed in a larger cell; at least each of them is surrounded by a well-defined ring, which however is more opake than the cell which it encircles (figs. 20 and 21*). From the mouth the gullet leads downward and forwards to the stomach (fig. 20 *h*), and from the back part of the stomach the intestine (fig. 20 *i*) commences. The intestine bends to the right, proceeding upwards on this side, and terminates a little below and behind the right transparent cell in the root of the *foot*, and it is there surrounded by a portion of an irregular mass composed of a few cells (fig. 20 *o*) occupying that position. The whole of the inner surface of the gullet, stomach and intestine is covered with cilia, and in some cases, masses, chiefly composed of what appeared to be minute cells thrown off from the inner surface of the digestive tube, were revolving rapidly in the stomach. Two masses adhered to the lateral surfaces of the stomach and lower part of the gullet (fig. 20 *m* and *n*); one of these, by much the larger (*m*), was placed on the left side, and projected considerably in front of the stomach; the other adhered to its right side (*n*), and was placed immediately in front of the upper part of the intestine. Each of these two bodies was composed of a single cell only, having minute cells or nuclei similar to those originally composing the ovum, scattered over its inner surface with considerable intervals between each. In several cases some minute

* Van Beneden supposes that these transparent cells which he observed in the embryo of the *Asplysia* may be the rudiments of the nervous system. This opinion may be true, but at present it must be considered only in the light of a supposition. These cells, if I mistake not, may be occasionally seen vibrating slightly within the larger cells inclosing them. It has been suggested to me that these may be the rudiments of the auditory organs.

bodies were seen moving backwards and forwards in the interior of the largest of these two cells*. On the right side there is an irregularly-shaped aperture (fig. 16 *t*) immediately behind the termination of the intestine, and between the upper part of the body and the aperture of the shell, through which the water passes into the interior, and cilia were seen in active motion in this situation. A band passes from the upper part of the mass of cells placed at the termination of the intestine, round the neck of the embryo, close to the margin of the aperture of the shell, and forms the outer boundary of this opening by which the water passes into the interior of the shell†. As the largest of the cells, placed at the termination of the intestine, was seen to contract at irregular intervals, I imagined that it might be a rudimentary heart, and the band to be a vessel leading from it, but I obtained no satisfactory evidence of the accuracy of this supposition. A pyramidal-shaped mass projects from the upper and back part of the body (fig. 20 *s*), from the apex of which a thin membrane descends and passes round the body (fig. 20 *v*). A strong band of contractile fibres is attached to the lower part of the left side of the shell, and passing up on the same side divides into two portions, which terminate upon the back part of the neck and gullet. A very minute band passes from the same part of the shell to the lower part of the stomach. These muscular bundles, though distinctly seen, especially the strong band passing upwards, in the embryos of all the Nudibranchiate Mollusca examined, are remarkably distinct in that of the *Dendronotus arborescens* (figs. 22 and 23 *p p* ‡). It is by the contraction of these muscular bundles that the animal retreats into its shell, causing the descent of the posterior portion of the *ciliated discs*, and the parts to which the muscular fibres are attached. I could not make out the position and course of the muscular bundles by which the embryo protrudes the *ciliated discs* and *foot* from the shell. The upper and anterior part of the body a little below the base of the *foot* is attached to the anterior margin of the shell, so that it undergoes little change of position during these movements of retraction and extrusion. The whole structures of the embryo are much more transparent than at an earlier period of its development, no minute cells or nuclei now adhere to the inner surface of the shell, and their number in the other parts is much diminished. The other parts of the embryo ap-

* The nuclei adhering to the inner surface of the larger of these two cells appeared bigger than the nuclei of which the ovum was originally chiefly composed, and also than those in the other parts of the embryo.

† This band is more distinctly seen in the embryo of the *Dendronotus arborescens*.

‡ This muscular bundle is indistinctly indicated in fig. 19.

pear to be formed of a soft texture without any definite structure, having minute cells or nuclei scattered at short intervals through it. Some of the embryos escape from their *case-membranes* at an earlier stage than this, and their structures are consequently more opake.

We now return to the earlier stages of the development. At the end of the ninth day the embryo had the appearance represented in fig. 15. The *ciliated discs* (*c*) and *foot* (*d*) were now distinctly seen, the central mass had separated itself to a greater distance from the shell (*a*), except at the upper part, and the portion within the shell had arranged itself into four imperfectly defined lobes, which are readily recognised to be earlier conditions of the structures described in the embryo when it is about to leave the *case-membrane*. The ciliated discs were however still small, but the embryos had now a greater or less degree of motion; some performing a rocking motion, and others more advanced were rotating slowly round the interior of the *case-membrane*. Besides the large cilia on the margins of the *ciliated discs*, smaller cilia were observed on different parts of the upper end of the embryo. The mouth was distinctly seen, the hard plate on the lower surface of the *foot* had begun to form, and the transparent cells in the base of the foot were seen on subjecting the embryo to pressure. A layer of the minute cells or nuclei covered the inner surface of the shell, giving it a considerable degree of opacity. From the ninth to the eleventh day the *ciliated discs* had become more developed, more separated from each other, and much more moveable. The largest of the four lobes of the body had arranged itself into a stomach and intestine, and occasional contractile movements were seen in these; and the transparent cells in the base of the *foot* were now very obvious. On the twelfth day the embryo had assumed the appearances represented in figs. 16, 17, 18 and 19, and all the parts described in it at the time of its leaving the spawn were now distinctly seen. Fig. 16 is an anterior view, showing that the two large cells at the side of the stomach are at this period connected by a ridge running across the front of the gullet, and which afterwards nearly disappears. The larger or left cell does not at this period project so much in front of the stomach, and the right cell is larger and lies near the anterior edge of the stomach. Fig. 17 is a view of the right side, showing the whole course of the intestine; fig. 18 is a view of the left side, in which the commencement of the intestine (*i*), curving itself to the right side, is the only part of that tube seen; and fig. 19 is a view of the posterior surface, showing the tortuous course of the intestine (*i*). The cilia on the inner surface of the stomach and intestine are now also visible. The course of the gullet is not yet distinctly seen, and all the structures are much more opake. The loose membrane surrounding the body at a later period (fig. 20 *v*) adheres to the inner surface of the shell, and like the other soft textures and the retractor muscle, contains numerous small cells or nuclei. At this period the embryo was never seen to draw the *ciliated discs* within the shell.

The ova of the other Nudibranchiate Mollusca examined passed through the same stages of development as those of the *Doris bilamellata,* and the embryos presented, with some slight modifications in size and position, the structures we have described. The embryo of the *Doris tuberculata,* at the time it leaves the *case-membrane,* is larger than the others, measuring about 1-100th of an inch in length and 1-130 in the antero-posterior direction; that of the *Dendronotus arborescens* measured 1-165 in length, and 1-250 in the antero-posterior direction; and that of the *Doto coronata* about 1-200 in the former and 1-260 in the latter direction. The shell of the embryo of the *Doris tuberculata* is relatively shorter in length or in the vertical direction than in the other embryos examined, and the parts which protrude beyond the shell are not only positively but relatively larger. The *ciliated discs* are especially large, the apex of the *foot* is narrower and more pointed, and the transparent cells in the base of the *foot* are relatively smaller. The gullet and stomach are short, and the two large cells at their lateral surfaces are placed near each other at a later period of its development than in the *D. bilamellata.* The cells at the termination of the intestine are more numerous and transparent, and occupy a considerable space of the upper part of the right side of the shell, so that the body of the embryo lies more to the left than to the right side of the mesial line of the shell.

The cilia were not observed on the upper part of the ovum of the *Goniodoris Barvicensis* and *Polycera quadrilineata* until the seventh day, or one day later than in that of the *D. bilamellata,* and the embryos of the *Polycera* did not begin to leave the spawn until the eighteenth day. The transparent cells in the base of the *foot* are, from the less opacity of the body, seen at an earlier stage in the embryos of the *Polycera* (fig. 14 *x*), and in a great number of these also at this stage, an opake irregular patch, composed at least partly of aggregated cells, lay on the surface of the lower end (fig. 14 *b*). The development of all the ova of the same spawn does not proceed *pari passu,* but much greater irregularities were observed in the ova of the *Polycera quadrilineata* than in the others; for in many of these the bipartite division did not even proceed regularly, nor were the cells into which it divided of the same size. That these irregularities were not entirely dependent upon the artificial conditions under which the spawn was placed, is rendered probable by the circumstance that they were seen in portions of spawn, in which, to judge from other portions of the same spawn examined at a later period, all these irregularities disappeared at a more advanced stage of their development. The external form of the embryo of the *Dendronotus arborescens* presented a much greater departure from that of the *Doris bilamellata* than any of the others. Fig. 22 is a representation of the left side, and fig. 23 of the right side of the embryo of the *D. arborescens* as it was leaving the *case-membrane*. The shell (fig. 24) was more elongated in the vertical direction, the embryo occupied a smaller portion of the shell, and the parts which project beyond it were relatively considerably smaller. All the textures were transparent, and the retractor muscles were very distinctly seen. The membrane surrounding the body (*v*) was attached to the shell around the origin of the retractor muscles. When it retired within the shell, the *ciliated discs* and *foot* were drawn down to a considerable distance from the orifice of the shell. When examined at an earlier period of its development, the whole embryo was decidedly shorter and much less transparent. I have had no opportunity of examining the embryos of the *D. arborescens*, except when developed under artificial circumstances, but the embryos possessing the appearances described, seemed healthy and active.

To what extent the artificial circumstances under which the ova of these animals were kept, influenced the period of time occupied in their development, we are not prepared to form an opinion. That the changes of structure described are those that occur in ova of the *Doris bilamellata* and *D. tuberculata* when left in the situations where they are usually deposited, was proved by the examination of portions of the spawn removed at different periods after deposition upon the rocks. The development of the ova of the *Doris bilamellata* proceeded more favourably than that of the others; but sometimes a considerable number even of these had their development arrested, and otherwise rendered monstrous, though supplied daily with water fresh from the ocean. I have as yet failed, though I have made the attempt in various ways, to keep the embryos alive after they leave the spawn, sufficiently long to trace the further stages of their development. Sars* and Messrs. Alder and Hancock† have already announced that the young of the Nudibranchiate Mollusca undergo metamorphosis, that they swim about for a time inclosed in a nautiloid shell, and that at this period they differ

* Wiegmann's 'Archives' for 1841. I have not seen Sars's paper, and quote this reference to it from Alder and Hancock.

† Report of the British Association for the Advancement of Science, volume for 1844, p. 27.

entirely in their external form and in their organism from their parents.

I may here mention that three of the *Dendronotus arborescens*, which I kept alive at home for nearly a month, often emitted very audible sounds, which were heard distinctly at the distance of twelve feet. Dr. Grant, who first noticed these sounds, supposes that they are produced by the action of the jaws. They exactly resembled the noise produced by a stroke upon the surface of the earthenware vessel in which they were kept, so that I at first imagined that it might be caused in this way, though it would be difficult to conceive how these animals could strike blows so forcible as to occasion so loud a sound. I however heard these sounds when it appeared to me that the animals were removed from the surface of the vessel and resting upon the branches of some zoophytes. Messrs. Alder and Hancock mention that they have frequently kept these animals for several days together without detecting the emission of any sound. It is possible that the animal emits this sound only during the breeding-season.

EXPLANATION OF PLATE X.

Fig. 1. Ovum of *Doris bilamellata* : *a*, case-membrane (chorion) ; *b*, yolk or vitelline mass.

Fig. 2. Part of the vitelline mass evacuated, showing the vitelline membrane ; *a*, small clear cell, sometimes seen attached to outer surface of vitelline membrane.

Fig. 3. Small cells (nuclei) forming the greater part of the vitelline mass.

Figs. 4, 5. First or bipartite division of the yolk.

Figs. 6. 7, 8, 9, 10, 11. Subsequent divisions of the yolk.

Fig. 12. Greatly enlarged view of one of the numerous cells into which the yolk ultimately divides.

Fig. 13. Embryo on the eighth day after extrusion of the ova.

Fig. 14. Embryo of *Polycera quadrilineata* at the same period of its development.

Fig. 15. Embryo of the *Doris bilamellata* at the ninth day.

Fig. 16. Anterior view of the embryo of the *Doris bilamellata* at the twelfth day.

Fig. 17. View of right side of the same.

Fig. 18. View of left side of the same.

Fig. 19. Posterior view of the same.

Fig. 20. View of right side of the embryo when it is ready to leave the *case-membrane*.

Fig. 21. View of the same when it has retired within its shell.

Fig. 22. View of left side of the embryo of *Dendronotus arborescens* when about to leave its *case-membrane*.

Fig. 23. View of right side of the same.

Fig. 24. Anterior view of shell of *Dendronotus arborescens*.

Fig. 25. Lateral view of the shell of *Doris bilamellata*.